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SCOUT-VEHICLE AERODYNAMIC-NOISE MEASUREMENTS

(NASA RP-87)

Reprint

SCOUT-VEHICLE AERODYNAMIC-NOISE MEASUREMENTS

FOR A VARIETY of flight vehicles, aerodynamic noise is significant from the standpoint of exciting directly the vibration modes of the surface structure, causing sensitive equipment to malfunction and interfering with the normal duty functions of the vehicle occupants. Interest has been intensified in recent years in this problem because aerodynamically induced disturbances are inherently more important with regard to high-performance aircraft and launch vehicles. Although a large number of aerodynamic-noise studies have been made, most of these have been analytical in nature or have involved laboratory experiments rather than free-flight-type experiments.[1] It is particularly desirable to have full-scale free-flight data that apply directly to realistic ranges of flight conditions and for comparison with other studies.

The free-flight conditions for which aerodynamic-noise data are available [2-8] can be summarized briefly with the aid of Fig. 1. There the ranges of Reynolds numbers (a measure of the flow velocity relative to the viscosity of the fluid medium) associated with the operation of three types of test vehicles are plotted as a function of Mach number. As represented by the crosshatched area, it can be seen that data are available for fighter-type aircraft for Mach numbers up to 2 but for only a limited range of Reynolds numbers. As indicated by the hatched region, for bombers and transport-type aircraft the Reynolds-number range is more extensive but the Mach-number range is limited. Although several attempts have been made to obtain launch-vehicle measurements for the ranges indicated by the shading on the figure, until recently no comparable systematic data were available.

The purpose of this article is to present some results of a surface-pressure-measurement experiment accomplished on a Scout launch vehicle and for which systematic data were obtained for Reynolds numbers (based on distance rearward from the nose of the vehicle to the transducer location) up to about 400×10^6 and for Mach numbers up to about 4 (see Ref. 9). It should be noted that these data have direct application to the supersonic transport and to launch vehicles.

Mr. Hilton was graduated from Virginia Polytechnic Institute in 1957 with a B.S. degree in Mechanical Engineering. From 1957 to 1959, he was employed by the Douglas Aircraft Company, his work pertaining mostly to the in-flight measurement of noise and vibration. While at Douglas, Mr. Hilton participated in the DC-8 jetliner-certification program. Mr. Hilton entered on duty at the NASA Langley Research Center in late 1959 and is presently assigned to the Acoustics Branch of the Dynamic Loads Division. His assignments have included noise studies of large rocket-powered boosters and proposed V/STOL aircraft. He has also participated in studies of sonic-boom generation, propagation, and prediction, as well as effects of sonic booms on ground building structures and aircraft.

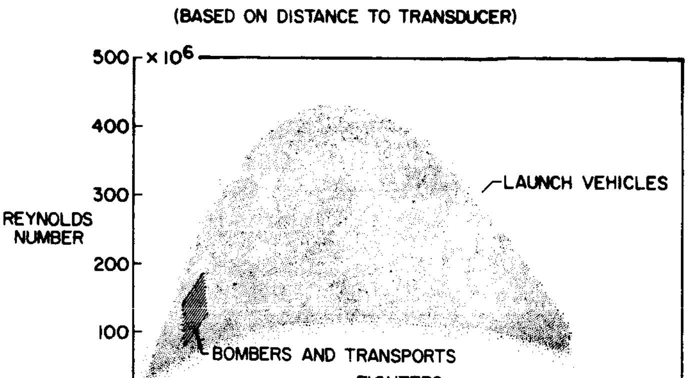

Fig. 1. Flight-data ranges of Reynolds number.

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Scout-Vehicle Performance and Description

The test-vehicle shape and significant dimensions, along with the onboard equipment, can be described with the aid of Fig. 2. The vehicle was roughly 72 ft (feet) in length with a maximum diameter of 40 in. (inches). The two microphone measuring stations were located approximately 34 and 68 ft, respectively, back from the nose. The nature of the onboard measuring and telemetering equipment is indicated by the photographs at the left-hand side of the vehicle. All of the onboard equipment, with the exception of the battery power supply and cabling, weighed about 4 pounds, and the largest dimension was approximately 7 in. The microphones had a diameter of about ½ in., were flush-mounted in the vehicle surface, and were connected to an FM telemeter transmitter through the associated amplifier and carrier equipment shown. These instruments, together with ground-station tape-recording equipment, provided a frequency range of about 50 to 10 000 cps (cycles per second) for each microphone channel.

The nature of the experiment, plus a schematic indication of the manner in which data were acquired, is shown in Fig. 3. The aerodynamic-noise equipment was carried as a "piggy-back" payload in conjunction with the launching of reentry payload. The vehicle was launched from Wallops Island, Virginia, and was tracked by means of a nearby radar facility. The telemeter system transmitted real-time noise data from both microphones, using one data link. The signal was received and tape recorded at the ground station, also located at Wallops Island. Usable data were obtained up to the time of second-stage ignition. Thus, the data included first-stage burning, during which time the

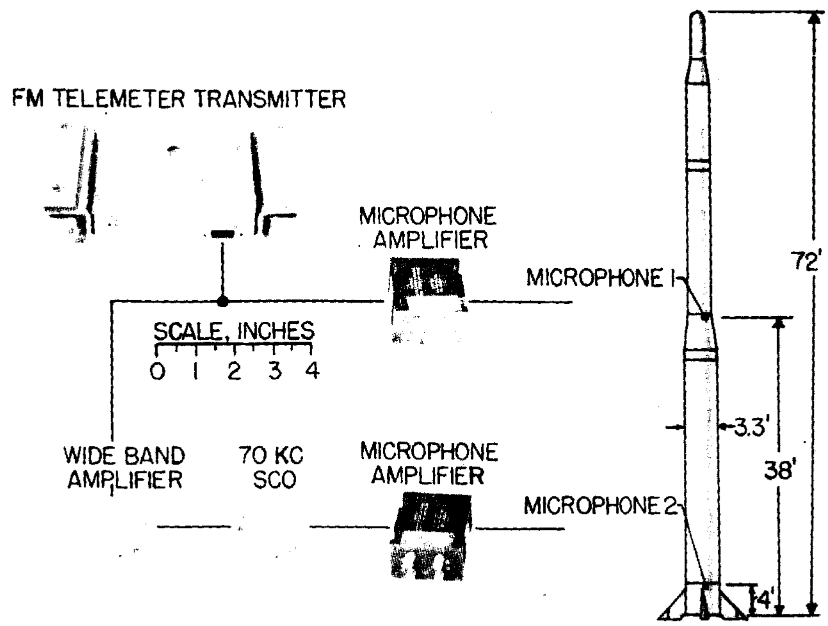
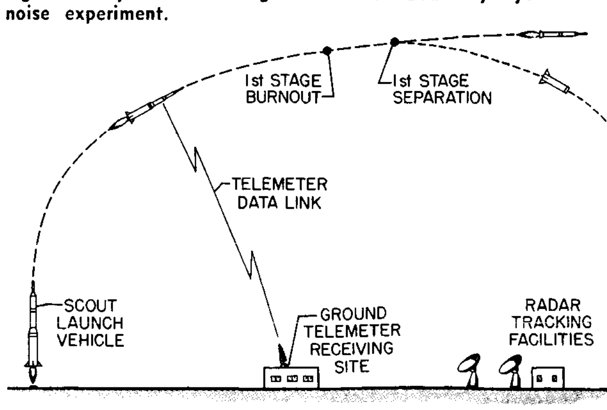


Fig. 2. Instrumentation for Scout launch vehicle.

Fig. 3. Acquisition of flight data for boundary-layer-noise experiment.



vehicle passed through the maximum dynamic-pressure condition and achieved a Mach number of about 4, plus the coast period between first-stage burnout and second-stage ignition. The maximum distance between the vehicle and the receiving station during the time of data acquisition was approximately 30 miles, at which time the vehicle was at approximately 100 000 ft altitude.

Presentation of Measured Data

As in some previous experiments, it was noted that the noise pressures increased as the free-stream dynamic pressure increased. This phenomenon is illustrated by the curves of Fig. 4 in which the vehicle free-stream dynamic pressure and the measured noise pressures are both plotted as a function of Mach number. It can be seen that at the lower Mach numbers the noise-pressure curve follows the dynamic-pressure curve quite closely. It can, however, be seen that the noise-pressure curve peaks at a lower Mach number than the dynamic-pressure curve and, furthermore, that there is a deviation from the dynamic-pressure curve at higher Mach numbers. This deviation may be explained in part by an apparent Mach-number effect, which is shown in Fig. 5 and which is explained in more detail during the discussion of Fig. 6.

This effect is illustrated by the data of Fig. 5 in which the surface coefficient $(\overline{p^2})^{\frac{1}{2}}/q$ is plotted as a function of Mach number for the data obtained at the two measuring stations. The supersonic portion of the solid curve suggests a trend toward reduced surface-pressure coefficients at the higher Mach numbers. The dotted portions of both curves at high Mach numbers correspond to flight conditions at high altitude and very low, associated dynamic pressures. The signal-to-noise ratios are rather low at these latter conditions, and thus the dashed curves are based on less-reliable data.

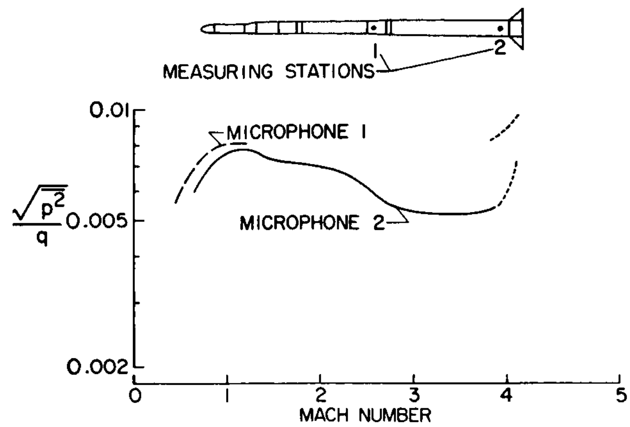


Fig. 5. Surface pressures measured on Scout vehicle.

Analyses of the recorded data have indicated a definite effect of Mach number on the spectral content of the measured pressures, and this effect is illustrated in Fig. 6. Data are presented here for microphone 2 at two different times in the flight for which the dynamic-pressure conditions were essentially equal but the Mach numbers were greatly different. The octave-band spectrum for a Mach number of 0.67 is shown by the circle symbols, and the octave-band spectrum obtained at Mach number 4.1 is represented by the square symbols. The spectra were noted to each have a single broad peak, and this peak moved to higher frequencies as the Mach number increased. In the specific case illustrated in Fig. 6, this peak in the measured spectrum is noted to change from the sixth octave at the lower Mach number to the eighth octave at the higher Mach number. The dotted curve represents corrections for microphone size for the Mach 0.67 data according to the method of Ref. 10. No corrections are shown for the Mach-number 4.13 case; however, it is believed that these would not be significant. The main conclusions presented here

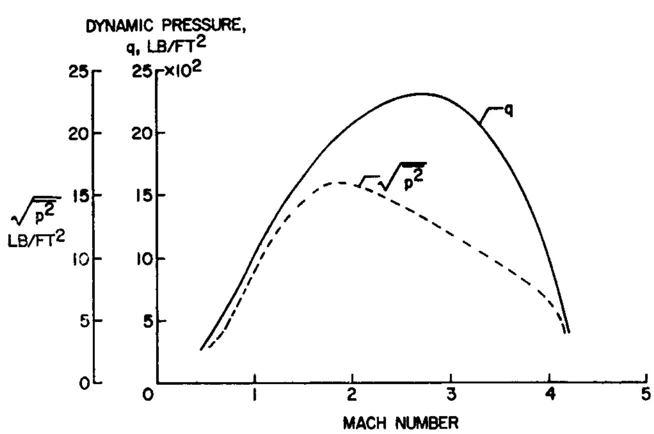


Fig. 4. Correlation of noise pressure and free-stream dynamic pressure.

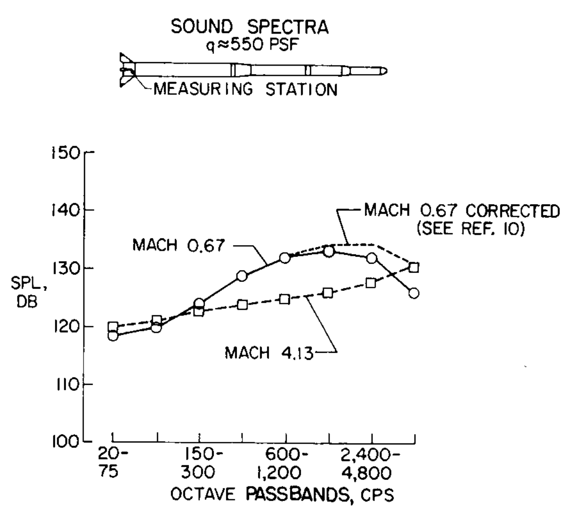


Fig. 6. Sound spectra.

are thus not influenced by the microphone-size correction suggested in Ref. 10.

There is a suggestion that the instruments did not have a sufficient frequency range to measure all the significant frequency components at the higher Mach numbers. Thus, there is a tendency to underestimate the surface-pressure levels at the higher Mach numbers, and this would account, in part at least, for the effects noted at the higher Mach numbers in Figs. 4 and 5.

Comparison with Other Data

The range of pressure-coefficient values measured for the Scout vehicle is compared with similar data from other free-flight studies in Fig. 7. It can be seen that these data compare favorably in magnitude with those measured for the B-47 and B-57 aircraft,[5, 6] as indicated in the figure, and for which the Reynolds numbers were of comparable magnitude. These values are considerably higher than those measured on the nose cone of a fighter aircraft [4] for which the Reynolds numbers were much lower, and hence the local flow conditions might have been considerably different. The Scout-data values are notably lower, however, than those measured for the Mercury spacecraft,[8] which had rough external contouring and possible associated flow separation and shock-wave interactions.

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A brief discussion has been given of an experiment in which aerodynamic-noise data at high Reynolds numbers were obtained in the supersonic-speed range with the aid of a launch vehicle from which real-time information was telemetered to a ground recording station. The results of this experiment indicate a shift in spectrum shape as a function of Mach number, the higher frequencies being associated with the higher Mach numbers. Another result suggests that the surface-pressure coefficients at supersonic Mach numbers do not vary markedly from those at subsonic Mach numbers for comparable flow conditions.

AUTHOR

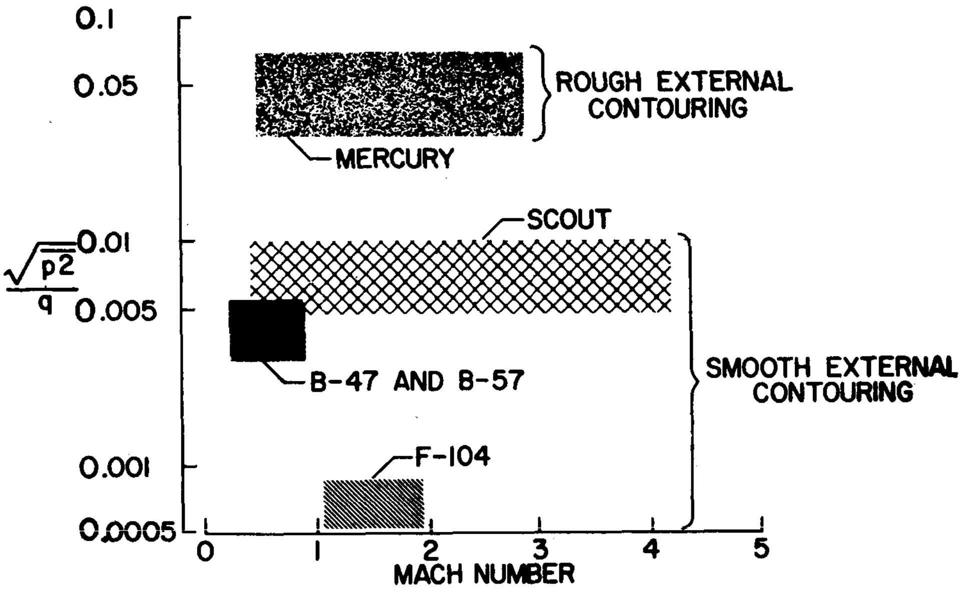

Fig. 7. Boundary-layer noise-pressure coefficient.

1. Alan Powell and T. J. B. Smith, "A Bibliography on Aeronautics," Univ. Calif. Dept. Eng. Rept. No. 62-4 (February 1962).
2. Frank J. Leech and Virgil E. Sackschewsky, "Boundary Layer Noise Measurements of the F-102 Aircraft," Wright-Patterson AFB, Ohio, MRL-TDR-62-71 (August 1962).
3. Harold R. Mull and Joseph S. Algranti, "Flight Measurements of Wall-Pressure Fluctuations and Boundary-Layer Turbulence," NASA TN D-280 (1960).
4. L. Maestrello, "Boundary-Layer Pressure Fluctuation on 707 Prototype Airplane," J. Acoust. Soc. Am. **34**, 1983(A) (1962).
5. Russell D. Shattuck, "Sound Pressures and Correlations of Noise on the Fuselage of a Jet Aircraft in Flight," NASA TN D-1086 (1961).
6. Norman J. McLeod and Gareth H. Jordan, "Preliminary Flight Survey of Fuselage and Boundary-Layer Sound-Pressure Levels," NACA RM H58B11 (1958).
7. Norman J. McLeod, "Flight-Determined Aerodynamic-Noise Environment of an Airplane Nose Cone up to a Mach Number of 2," NASA TN D-1160 (1962).
8. William H. Mayes, David A. Hilton, and Charles A. Hardesty, "In-Flight Noise Measurements for Three Project Mercury Vehicles," NASA TN D-997 (1962).
9. D. A. Hilton, E. M. Bracalente, and H. H. Hubbard, "In-Flight Aerodynamic Noise Measurements on a Scout Launch Vehicle," NASA TN D-1818 (1963).
10. G. M. Corcos, "Resolution of Pressure in Turbulence," J. Acoust. Soc. Am. **35**, 192 (1963).